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SIR WILLIAM RAMSAY, K.C.B.

(*Read May 4, 1917.*)

In the untimely death of Sir William Ramsay the American Philosophical Society has lost one of its most distinguished members, the world of science a leader of rare insight and initiative, England one of her most brilliant men, and his intimates a much prized friend. He possessed a personality of unusual charm, charged with wide interests, keen human affections, and vivid enthusiasms.

The only son of William Ramsay, a well-known civil engineer, and Catherine Robertson Ramsay, the child destined later to develop into a great chemist was born at Glasgow on the 2d of October, 1852. He early turned his attention toward science, and believed his talent in this direction to have been inherited from his grandparents on both his father's and his mother's side—for he came of families of physicians and naturalists. After preliminary education at the Glasgow Academy, he entered the University of Glasgow when only fourteen years old, taking at first a general course, and later turning his attention especially toward chemistry. In 1870, at the age of eighteen, his chemical studies had progressed so far that he was anxious to seek further light in Germany, and in the autumn of that year was able, in spite of the Franco-Prussian war, to go to Heidelberg in order to study under Bunsen. Shortly afterwards he turned toward Tübingen, where he worked for nearly two years under Fittig, and gained his doctor's degree by virtue of a dissertation upon ortho- and meta-toluic acid.

In the autumn of 1872 the young doctor of philosophy of twenty summers returned, full of enthusiasm, to his native city, and became assistant in the "Young" laboratory of technical chemistry there. Two years later he was made tutorial assistant in the University of Glasgow. In spite of his charge of the elementary class of 200 students he found time to undertake investigations concerning many diverse fields of chemistry; for his interest was wide, and only as the years advanced did he put most of his energy into the swiftly growing branch of physical chemistry, which finally came to claim most of his attention.

His studies on picolin and quinine were partly ready for publication in 1876, and in 1879, while still at Glasgow, he published an important investigation concerning molecular volumes of liquids at their boiling points, a research for which he devised peculiarly ingenious apparatus. His interesting preliminary study of the chemistry of the sense of smell dates from about the same time, and, taken together with the others, shows the breadth and scope of his interest.

In the next year Ramsay was called to the professorship of chemistry in the University of Bristol, where he remained seven years, and where he found Sydney Young, an able collaborator, with whom he published many papers between 1882 and 1889. These papers especially concerned vapor pressure, and dealt not only with the vapor pressure of solid and liquid substances, but also with the dissociation of ammonia and nitrogen trioxide, as well as with the critical point. During the last six of his years at the University College, Bristol, Ramsay was principal as well as professor of chemistry.

In 1887 he resigned both positions in order to accept the chair of chemistry in University College on Gower Street in London, this chair having been left vacant by the death of Williamson. Ramsay was one of the first to see the far-reaching importance of the new theory of solutions brought forward by van't Hoff and Arrhenius, as was shown by the fact that he published in the *Philosophical Magazine* an English translation of van't Hoff's epoch-making paper. Not only in this way, but also by his own researches Ramsay advanced the new doctrines, and his investigations on the diminution of the vapor pressure of mercury by the presence of dissolved metals, as well as his interesting and important work on surface tension, bore witness to his faith in the new point of view.

At University College, where he remained until 1913, he carried out also the series of brilliant researches which constitute his chief title to fame, namely, those concerning the inert gases of the atmosphere. Lord Rayleigh, in a research which is a model of experimental acumen and conscientious execution, was the first to suspect the existence of such gases; his careful study of the density of nitrogen from different sources had proved chemical nitrogen (prepared from nitric acid and ammonia) to be distinctly less in density than the residue of the atmosphere from which oxygen and carbon dioxide had been separated. Lord Rayleigh had shown that the difference was not due to any impurity of hydrogen in the chemically prepared nitrogen, and that hence it must probably be due to an unknown impurity in the atmospheric nitrogen. He had begun on the task of burning this rather incombustible gas with the help of the electric spark, in order to discover the nature of the residue, a task which Cavendish long before had crudely attempted, and which is now executed on a huge scale commercially. Ramsay, stimulated by Lord Rayleigh's experiments and by the latter's request for air from chemists, suggested another method of fixing atmospheric nitrogen by conducting the gas over heated magnesium. The two investigators worked in harmony, and in 1894 succeded in showing that the residues left after the nitrogen was combined by these two different methods were identical; and that this common residue consisted primarily of a hitherto unsuspected gas, which they named argon, existing to the extent of about 1 per cent. in the atmosphere. Sir William once told me that on hearing of Lord Rayleigh's first experiments and turning to the original description of Cavendish's experiments in his own library, he found the pencilled annotation, "Look into this matter," placed opposite the line where Cavendish states that a small bubble, not over 1 per cent. of the whole, remained unconsumed by the sparking with oxygen. If Ramsay had followed this early suggestion of his own, he, instead of Lord Rayleigh, might have been the first to point out that the small bubble remaining in Cavendish's experiment, was probably a hitherto unknown gas. As it was, Ramsay's greatest credit lay especially in his later work in this field. Remembering a discovery of Hillebrand's that an inert gas had been found to exist included in a certain ore of uranium, Ramsay secured a specimen of this ore in order to discover if this gas might not be argon. To his amazement he found that the gas possessed a different spectrum, the chief yellow line in which was identical with that in the spectrum of the sun ascribed to an element, unknown on earth, called helium. Before Ramsay's discovery this substance had indeed been suspected in the spectrum of volcanic ejections from Vesuvius, but no one had any idea of its nature. The excitement of the discovery was so great that Ramsay was obliged to voyage to Iceland for a long rest.

The existence of two inert gases with atomic weights respectively about 4 and 40 suggested to Ramsay the possibility that there might also be others fitting in to other corresponding places in the periodic system of the elements; and after an eager search, in a brilliant investigation, Ramsay announced the discovery of the whole series, including neon, crypton and xenon, obtained by fractional distillation at very low temperatures of the residues from large amounts of liquid air or liquid argon. This work was carried out with the help of Travers, using the methods for the liquefaction of the so-called permanent gases which had only recently been developed by others. It was about this time, between 1895 and 1898, that I remember Sir William's having said to me: "Nothing in this world is too strange to be true if properly substantiated by adequate experiments." This feeling animated Ramsay in all his researches, and was a good preparation for the yet more astounding things which were to come. For during these years the extraordinary properties of radium and the revolutionary phenomena of radioactivity began to become known to mankind, and Ramsay, with eager interest in anything capable of throwing new light upon the processes of nature, welcomed to his laboratory Frederick Soddy, who had just come from Montreal, where he had helped Rutherford in his epoch-making studies concerning this subject. It was Ramsay's admirable technique in dealing with small quantities of gases that enabled him, in collaboration with Soddy in 1903, to give the first experimental evidence that helium is formed from radium—a phenomenon suspected by Rutherford, but not experimentally proved by him. Soon afterwards, in 1908, with the help of Cameron, Ramsay showed that the emanation from radium, which had been proved by Ramsay's earlier work with Gray to be a heavy but unstable gas, had, in spite of its instability, a spectrum of its own.

It is not surprising that an enthusiast confronted with the decomposition of so many substances, which in so many respects appeared to be classed among the elements, should push the idea too far and fall into an almost alchemical state of mind. Ramsay's later experiments, in conjunction with Cameron and Usher, in which they thought that radium emanation could decompose copper into lithium and thorium into carbon, have not been verified by other experimenters. Perhaps it is premature to judge the outcome; but if the conclusion was an error, it must be remembered that the person who has never made a mistake is one who has never attempted any serious work.

More fortunate, as it appears at present, was Ramsay's later research with Gray on the density of the radium emanation, called by him "niton." This important investigation, carried out with extraordinarily small quantities of material, proved the transitory "niton" to be the heaviest member of the argon series, and showed that it fits satisfactorily into its appointed place in the periodic system, as well as into the expected niche in the Soddy-Fajans disintegration series.

The work indicating the true nature of niton appropriately crowned Ramsay's work upon the series of inert gases, the discovery of which was so largely due to his insight, enthusiasm and perseverance.

In addition to all his brilliant researches Ramsay found time to publish a number of books, the chief of which were: "A System of Chemistry" (1891); "The Gases of the Atmosphere" (1896); "Modern Chemistry" (1901); "Essays, Biographical and Chemical" (1908); and (as editor) a series of very valuable textbooks upon the different subdivisions of physical chemistry. In 1911 he was president of the British Association for the Advancement of Science, and his address, which began with a review of the amazing discoveries of recent years, ended with an impressive warning as to the impending failure of the world's coal supply, especially that of Britain, with its direful consequences; but this warning has fallen largely upon deaf ears, and the world continues to squander the stored energy of the ages with reckless prodigality.

As would be expected, honors were showered upon this rare intellect from all sides. He was created K.C.B. in 1902 and received the Nobel prize in chemistry in 1904, besides having had various orders and medals conferred upon him, and having been made an honorary member of nearly all the learned academies and chemical societies of the world. Many of these distinctions came from Germany, where he formerly had warm friends; but on the outbreak of the war his patriotism and his sense of justice and honor made him a firm and outspoken upholder of the cause of the Entente Allies, and even during his lingering and painful illness he did all in his power to help his country in her time of need. In 1881 he married Miss Margaret Buchanan, who survives him, with one son, one daughter, and three grandchildren. He died, all too soon, on the 23d of July, 1916, in his sixty-fourth year, at his country estate at Haslemere in Bucks, England.

Ramsay, in his own brief autobiographical sketch, has acknowledged freely the debt which he sometimes owed to others for ideas and suggestions, proclaiming his belief that scientific men should help one another and seek help whenever they could, and adding that he always endeavored to acknowledge specific cases of indebtedness to others whenever possible. Nevertheless, he was full of initiative and originality himself. The study of his work shows that the following were among the attributes of his genius: an intense curiosity and enthusiasm with regard to everything new, an excellent experimental technique in dealing with gases, a great fertility of fruitful ideas, a daring scientific imagination, and devoted persistence in any promising line of work. The happy aggregation of these and other qualifications led Ramsay to successes significant enough to put his name high on the roll of the leaders of chemistry for all time. To him science owes a priceless debt for investigations which, in the short space of a score of years, made an unparalleled contribution, in that they revealed to the world a whole group of hitherto unknown elements possessing properties both unexpected and unique.

THEODORE W. RICHARDS.